Annals of Plant Sciences 6.12 (2017) pp. 1879-1885

ANNALS OF PLANT SCIENCES
ISSN: 2287-688X
OPEN ACCESS
www.annalsofplantsciences.com

Short Communication

A review on phycological studies with special emphasis on Kashmir Himalayan Valley: Algal Biodiversity

Javeed Ahmad Lone[1]*, Farooq Ahmad Lone[1], Mekhla Ratna Suseela[2]

[1]Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir 190 025, India.

[2]Algology Section, Conservation Biology and Biodiversity Division, National Botanical Research Institute, Lucknow, Utter Pradesh 226 001, India.

Received: 2017-11-01; Revised: 2017-11-27 **Accepted:** 2017-11-29

Abstract: The present communication has documented the role of different researchers regarding the biological diversity of freshwater algal species representing various groups and distributed in diverse freshwater habitats around the globe and in India with special emphasis on Kashmir valley of Jammu and Kashmir, India.

Keywords: Algae, Biodiversity, Distribution, Freshwater, Kashmir valley.

Introduction

Algae are a diverse group of simple plants ranging from unicellular to multicellular form and are considered as the first autotrophic plants of the planet. They are very small, single-celled to complex multicellular forms, such as the gaint kelps of the eastern Pacific Ocean that grow to more than 60 meters in the length and form dense marine forests. They comprise nearly one-third part of world plant biomass of the earth and are ubiquitous, that occur in almost all habitats, ranging from marine and freshwater to desert sands and from hot springs to snow. The habitats occupied by freshwater algae are divided into lotic and lentic water types. Algae are placed at the lowest rung of evolution and serve as a base model for the origin of land plants. They have enormous economic implications, not only as primary producers and pollution indicators (Prasad & Singh 1996) but also as a source of several natural products, biofertilizers and fine chemicals. They are an inseparable associate of the environment and also help in the purification of the environment. The early accumulation of oxygen in the earth's atmosphere was due to photosynthesis of ancient algal forms. It is estimated that the algal photosynthesis contributes nearly 90 percent of oxygen release in the earth's atmosphere. Globally algae are considered to fix 50 percent of CO_2 and are the primary producers in aquatic habitat supporting rich food chains and oxygenate the aquatic systems (Misra *et al.,* 2001). Scientists have estimated the total number of algal species to over 50,000 in the world but only 30,000 species are identified and examined (Frac *et al.,* 2010). Even fewer species are really tried out biotechnologically for industrial purposes. Algae are especially effective in converting carbon dioxide and other nutrients into organic compounds. An algal facility could be sited next to a power plant or industry that burns fossil fuels and could recycle part of the carbon dioxide from flue gases into liquid fuels. Thereby shall help us to reduce its emissions in the atmosphere and combating climate change.

Comprehensive research work has been done on the biological diversity of freshwater algae around the globe and to get the latest algal floristic data, an attempt has been made in this review paper to carry out the documentation in order to consolidate the available work on freshwater algae carried by different researchers.

Algological studies - A glance of global scenario

The progress of algological studies around the globe has been reviewed for last more than five decades. The work has been extensively done on Chlorophyceae, Cyanophyceae, Bacillariophyceae and Rhodophyceae. The 19th Century witnessed a great spurt in algal studies: From 1817-1824 Agardh carried out a study on the algal flora of Scandinavia. Ralfs (1848) studied desmids of Britain. A great contribution came from Kuetzing (1845-1849) who authored a great number of genera than any phycologists before and described many species. Afterwards, from 1891 Borge carried out an extensive research on the algal flora of Germany as well as on the collections received from China and Paraguay. West & West (1895, 1897-1898) have given a detailed taxonomical enumeration of freshwater algae from Madagascar, North America and Singapore. A monograph of British Desmidiaceae was prepared by West *et al.,* in 1923. The freshwater algae of South Africa particularly from Natal and Transvall cape colony were studied

***Corresponding Author:**
Dr. J. A. Lone
Division of Environmental Sciences,
Sher-e- Kashmir University of Agricultural Sciences and Technology-Kashmir,
Srinagar, Jammu and Kashmir, 190 025, India.
E-mail: javeedevs@gmail.com

by Fritsch & Rich (1924, 1937). The freshwater algal flora of Ceylon was reported by Crow (1923). Handa (1927 a, b) has made an important contribution to the freshwater algae from Rangoon. Prescott (1931, 1935, 1936 a, b & 1937) reported desmid flora of Iowa, New England, Western United States, Gatun Lake, Panama Canal, Isle and Michigan. Prescott & Magnotta in 1935 gave notes on Michigan desmids.

A study of the algal flora of Britain was carried out by Lund (1942-1960) who recorded species like *Chlamydomonas, Scenedesmus* and few new forms. The structure and reproduction of algae were explored by Fritsch (1945). Some freshwater algae from North America were reported by Prescott *et al.,* (1949). Prescott & Scott (1945) and Prescott (1951) carried out extensive work on the freshwater algae of United States of America. The algae of Illinois were reported by Tiffany & Britton (1952). Indonesian freshwater algae received a considerable attention from Scott & Prescott (1956, 1958 and 1960) who prepared notes on them. Coessel (1975, 1979, 1984, 1988, 1989 & 1993) made significant contributions to Dutch desmid flora & Coessel (2000) also studied the desmid flora of Thailand. Pham *et al.,* (2011) prepared a checklist of the algae of Singapore. Freitas & Loverde-Oliveira (2013) prepared a checklist of green algae for the State of Mato Grosso, Central Brazil.

Phycological research in India

In the eighteenth and nineteenth century, great advances have been made in the field of Algology, especially on Cyanophyceae, Chlorophyceae, Bacillariophyceae and Rhodophyceae throughout the Indian subcontinents. During the last 60 years, several standard publications on morphology and taxonomy of various algal groups were credited to prominent algologists like Desikachary (1959) on Cyanophyta, Randhawa (1959) also added new dimensions to the study of Zygnemataceae. Ramanathan (1964) on Ulotrichales, Philipose (1967) on Chlorococcales while Iyengar and Desikachary (1981) on Volvocales, Gonzalves (1982) on Oedogoniales. Likewise Anand (1989) came up with publications on Blue green algae.

Ehrenberg (1854) was the first worker who studied the geographical distribution of various species of Diatoms particularly from Bengal in India. Turner (1892) published a memoir of the East Indian freshwater algae. Turner in his work incorporated 22 species of Myxophyceae, 542 species of desmids and 60 species of Chlorophyceae exclusive of desmids. West & West (1902) described 7 species of Rhodophyceae, 49 species of diatoms, 33 species of Myxophyceae, 246 species of desmids and 34 species of Chlorophyceae from Ceylon. West & West (1907) recorded 58 species of diatoms and 148 species of desmids as well as 53 species of blue-green algae from Madras and Burma. Ghose (1923, 1927b) has given systematic and ecological accounts of blue-green algae from Lahore, Shimla and Rangoon areas. Bharadwaja's (1928-64) notable contribution was on the Cyanophycean flora of Uttar Pradesh, India. The distribution of Ulotrichales algae in India was extensively studied by Ramanathan (1964) in his monographic work. Randhawa (1934, 1936b, c, 1938, 1940, 1941b, 1943, 1958, 1959) extensively studied and made significant contributions on Zygnemataceae and Chaetophoraceae. The occurrence of Oedogoniales taxa in India has been reported by Singh (1936), Gonzalves & Sonnad (1961) from Mysore, Goyal (1964b) from Rajasthan, Bharati & Pai (1972b) from Mysore, Karnataka. Misra (1937) reported Zygnematales members from Kashmir valley of Jammu and Kashmir. The Cladophorales were recorded from different places of India by Balakrishnan (1954), Randhawa & Venkataraman (1961). Goyal & Venkataraman (1964) have described culture variations in the morphology of *Anabaena cycadeae* Reink. Chaturvedi & Pandey (1976) have listed 52 taxa of Cyanophyceae and Chlorophyceae from Rohilkhand, Uttar Pradesh India. Pandey & Pandey (1980) have studied 33 taxa under 15 genera of Bacillariophyceae from Allahabad, Utter Pradesh India. Mukhopadhyay & Chatterjee (1981) have compiled the description of 57 taxa of blue-green algae from Howrah district, West Bengal. Dickie (1882) described few interesting algae from Sikkim Himalayas. In 1984 Sankaran discovered a new species of genus *Batrachospermum* Roth named as *B. desikacharyil* from Tamil Nadu. Prasad *et al.,* (1986) enumerated 22 taxa of Cyanophyceae from Panchmarhi, Madhya Pradesh. Desikachary *et al.,* (1990, 1998) prepared a detailed account of Indian Rhodophycean algae from fresh as well as marine water habitats. A pioneer work on Chlorococcalean flora was done by Kaushik *et al.,* (1991) from Madhya Pradesh. Kant & Gupta (1998) have comprised 171 species of Cyanophyceae from Ladakh, Jammu and Kashmir. In the same year, they made an extensive survey of algal forms of Ladakh and recorded 286 genera, 848 species, 155 varieties, 27 forms and 6 combinations. Habib (2000) studied 25 taxa of diatoms under 10 genera described from foot hills of Garhwal Himalaya Uttaranchal. Habib (2001) has studied some Chlorococcalean taxa from foothills of Kumaun Himalaya. Suseela & Dwivedi (2001) reported 4 taxa of Chaetophoralean members from Bundelkhand region of Uttar Pradesh. Suseela & Dwivedi (2002) have made a great contribution to freshwater algal flora of class Bacillariophyceae from Bundelkhand region Uttar Pradesh. In the same year, Pattanaik & Adhikary (2002) have reported 16 taxa under 8 genera of Cyanophyceae from some archaeological sites and monuments of India. Khare & Suseela (2004) have enumerated 31 taxa of Cyanophyceae, Chlorophyceae and Bacillariophyceae from Nainital, Uttaranchal. Misra *et al.,* (2004) studied 17 taxa of 15 genera in

Cyanophyceae, Chlorophyceae and Bacillariophyceae from Sant Kabir Nagar, Uttar Pradesh. Suseela & Toppo (2007) enumerated the desmid flora of Sikkim Himalayas. Toppo & Suseela (2009) enumerated *Scenedesmus* species in Chhattisgarh State. Suseela & Toppo (2010) enumerated the occurrence of rare desmids and their addition to Indian algal flora. Suseela & Toppo (2011) studied the occurrence and diversity of *Staurastrum* species in lentic water bodies of Chattisgarh State. Cyanobacterial diversity (31 species) along with the physico chemical characteristics of a lentic ecosystem from the Gangetic plain has been studied by Bajpai *et al.,* (2013). Kumar *et al.,* (2013) studied the Cyanophycean flora of Kangra district of Himachal Pradesh. Singh *et al.,* (2014) explored the Chroococcales in river Ganga at Kanpur while Srivastava *et al.,* (2014) explored the Cyanobacteria of Sai River, Lucknow. Recently Jitendra & Anand (2016) recorded eight new records of fresh water filamentous algae (Oedogonium Link) from India.

Algal investigations in Kashmir himalayan valley

The pioneering studies on the Lakes of Kashmir have been initiated with the work of Kant & Kachroo (1973) reported the peak for Myxophyceae in October, Chlorophyceae in August, and Bacillariophyceae in January and February, and Cryptomonadineae in September-October, and Dinophyceae and Euglinineae in August-September, Bacillariophyceae had a secondary peak in October and monthly distribution of dominant genera was also represented graphically. Mir & Kachroo (1982) reported that in the Dal and Nagin lakes of Kashmir Himalaya, the main bulk of the phytoplankton comprises Bacillariophyceae with the highest standing crop in spring-summer interphase and depression in winter. They found that local meteorological disturbances and the shallowness of the lake cause erratic fluctuations in physico chemical parameters and alter the biological balance of the lake water. Zutshi & Vass (1982) studied the phytoplankton crop of the lake and reported that in general lake consist of members belonging to Chlorophyceae, Bacillariophyceae and Cyanophyceae. They also found significant site variation with regard to plankton distribution. Wanganeo & Wanganeo (1991) revealed that lakes in Kashmir manifested a marked change in algal assemblage with a change in physical and chemical environment. Khan (2002) consolidated first series on phycological studies in Kashmir and recorded a total of 889 documented algal species representing various groups and distributed in diverse freshwater habitats. Iqbal *et al.,* (2008) recorded a total of 134 species of phytoplankton and species like *Asterionella formosa*, *Pediastrum tetras* and *Tetraedron regulari* restricted their presence only near the regions receiving sewage outfalls and species like *Pediastrum ovatum*, *Merismopedia glauca* and *Trachelomonas* sp. were found only at open water sites. Shafiq-ur-Rehman (2009) found that the Dal lake of the Kashmir valley has suffered from formation of a rare phenomenon of red-bloom of a new species discovered as *Euglena shafiqii*. The nutrients have been found important factor for the periodicity and aggregation of *Euglena shafiqii*, since during the bloom period the nutrients were reduced, thus believed to be utilized by the organisms for growth. Ganai *et al.,* (2010) carried out studies on Wular lake and identified 64 phytoplankton spp. The most abundant species in terms of population density were *Amphora* spp., *Cyclotella* spp., *Navicula* spp. and *Nitzchia* spp. Chlorophyceae and Cyanophyceae showed a positive correlation with water temperature respectively at the selected site whereas Bacillariophyceae and Euglenophyceae showed the negative correlation with water temperature respectively. Lone *et al.,* (2016) identified a total of 22 algal genera comprising of 39 species, 6 varieties during the four seasons at six different sites of Dal lake. They also found that Rhodophyceaen algae *Glaucosphaera vacuolata* was monotypic in its representation and was reported during the autumn season at DLS-IV and is a new record reported to the phycological studies of India. Blue-green microalgae *Microcystis aeruginosa* was found abundantly at DLS-II indicating alarming toxic nature of water as this alga contains microcystins of neuro and hepatotoxins.

References

1. Agardh CA. Synopsis Algarum Scandinaviae, adjecta dispositione universali algarum, (1817-24): pp. 135.
2. Anand N. Hand book of blue green algae of rice field soils of South India. Bishen Singh and Mahendra Pal Singh, Dehradun India, (1989): pp. 79.
3. Bajpai O, Mishra S, Mohan N, Mohan J and Gupta, RK. Phyco chemical characteristics of Lakhna Devi temple water tank, Lakhna, Bakewar, Etawah, U.P. with reference to Cynobacterial Diversity, *International Journal of Environment,* 1.1 (2013): 20-28.
4. Balakrishnan MS. A new species of *Sphaerollopsis*. *Journal of the Indian Botanical Society,* 37.3 (1954): 382-386.
5. Bharadwaja Y. *Spelaeopogon kaspyapi* sp. nov. A new member of the Scytonemataceae. *Annals of Botany,* 42.165 (1928): 69-74.
6. Bharadwaja Y. *Scytonema malaviyaensis* sp. nov. *Rev. Algol,* 5 (1930): 223-227.
7. Bharadwaja Y. Contribution to our knowledge of the Myxophyceae of India. *Annals of Botany,* 47.185 (1933a): 111-143.
8. Bharadwaja Y. A new sp. of *Draparnaldiopsis* (*D. indica* sp. nov.) *New Phytologist,* 32.3 (1933b): 1-10.
9. Bharadwaja Y. The taxonomy of *Scytonema* and *Tolypothrix* including some new record and new

species from India and Ceylon. *Rev. Algol,* 7 (1934): 149-178.

10. Bharadwaja Y. Chlorococcales from Kodaikanal, South India. *Journal of the Bombay Natural History Society,* 61.2 (1964): 425-479.

11. Bharati SG and Pai KM. On the occurrence of some Oedogoniaceae in certain soils of Mysore state. *Journal of Karnataka University,* 17 (1972b): 132-139.

12. Borge O. Ett lilet bidrag Sibiriens Chlorophyceae. Flora Bis. Kongliga Svenska VetensKaps Aakademicns Handlinger 17, Afd., 3 (1891): 1-16.

13. Chaturvedi UK and Pandey UC. A list of blue green algae and green algae from Rohilkhand division, U.P., India. *Phykos,* 15 (1976): 127-131.

14. Coesel P.F.M. The relevance of Desmids in the biological typology and evaluation of fresh water. *Hydrobiological Bulletin,* 9.3 (1975): 93-101.

15. Coesel PFM. Desmids of the broad area of N.W. Overijssel (The Netherlands) 2. *Acta Botanica Neerlandica,* 28.6 (1979): 385-423.

16. Coesel PFM. Taxonomic implications of SEM revealed cell wall sculpturing in some small sized Desmid species (Chlorophyta, Conjugatophyceae). *Acta Botanica Neerlandica,* 33.4 (1984): 385-398.

17. Coesel PFM. Biosystematic studies on the *Closterium moniliferum* ehrenbergii complex (Chlorophyta conjugatophyceae) in western Europe II. Sexual Compatibility. *Phycologia,* 27 (1988): 421-424.

18. Coesel PFM. Taxonomic notes on Dutch Desmids. *Cryptogamie Algologie,* 10.3 (1989): 181-193.

19. Coesel PFM. Taxonomic notes on Dutch Desmids II. *Cryptogamie Algologie,* 14.2.3(1993): 105-114.

20. Coesel PFM. Desmids (Chlorophyta, Desmidiaceae) from Thale (Thailand). *Nordic Journal of Botany,* 20.3 (2000): 369-383.

21. Crow WB. Fresh water Plankton algae from Ceylon. *Journal of Botany London,* 61 (1923): 110-114, 138-145 and 164-171.

22. Desikachary TV. Cyanophyta. Indian Council Agricultural Research. Monograph on blue green algae New Delhi, (1959): pp. 686.

23. Desikachary TV, Krishnamurthy V and Balakrishan MS. Rhodophyta, monograph on red algae. T.T. Maps and publications Ltd., (1990): pp. 279.

24. Desikachary TV, Krishnamurthy V and Balakrishan MS. Rhodophyta II. Monograph on red algae. V. Subramanian and S. Viswanathan Pvt. Ltd., (1998): pp. 259.

25. Dickie G. Notes on algae from Himalaya. *Journal of Linnean Society, Botany* 19, (1882): 230-232.

26. Ehrenberg CG. Mikrogeologie das erden unde felsen schaffende wirken des unischtbar kleines selbstardigen lebens suf der erde, (1854): 1-374.

27. Frac M, Jezierska-Tys S and Tys J. Microalgae for biofuels production and environmental applications: *A review. African Journal of Biotechnology,* 9 2010): 9227-9236.

28. Freitas LC and Loverde-Oliveira SM. Checklist of green algae (Chlorophyta) for the state of Mato Grosso, Central Brazil. Check List. *Journal of species lists and distribution,* 9.6 (2013): 1471-1483.

29. Fritch FE and Rich F. Contribution to our knowledge of the fresh water algae of Africa. 4. Fresh water and subaerial algae from Natal. *Transactions of the Royal Society of South Africa,* 11(1924): 297-398.

30. Fritch FE and Rich F. Contribution to our knowledge of the fresh water algae of Africa XII. Algae from Belfast Pan Transuaal. *Transactions of the Royal Society of South Africa,* 25.2(1937): 153-288.

31. Fritsch FE. The structure and reproduction of the algae. Vol. II. Cambridge Univ. Press, London, (1945) pp. 939.

32. Ganai AH, Parveen S, Khan AA and Maryam H. Phytoplankton diversity at Watlab ghat in Wular lake, Kashmir. *Journal of Ecology and the Natural Environment,* 2.8(2010): 140-146.

33. Ghose SL. A systematic and ecological account of a collection of blue green algae from Lahore and Shimla. *Journal of the Linnean Society, Botany*, 46 (1923): 333-346.

34. Ghose SL. The Myxophyceae of Rangoon III. *Journal of the Burma Research Society,* 17.3(1927b.): 237-253.

35. Gonzalves EA. Oedogoniales. Monograph on Algae, Indian Council of Agriculture Research, New Delhi, (1982) pp. 757.

36. Gonzalves EA and Sonnad GR. The Genus *Oedogonium* in Mysore State. *Journal of the Bombay Natural History Society* 58, (1961): 715-723.

37. Goyal SK. Algal flora of Jodhpur and its environs III. Oedogoniales. *Ibid,* 61.2 (1964b): 385-395.

38. Goyal SK and Venkataraman GS. Cultural variations in the morphology of *Anabaena cycadeae* Reinke. *Ibid,* 3.1.2 (1964): 35-37.

39. Habib I. Diatoms from foot hills of Garhwal, Himalaya. *Journal of Economic and Taxonomic Botany*, 24.1 (2000): 104-106.

40. Habib I. Chlorococcales from foot hills of Kumaun, Himalaya. *Algal Biotechnology,* (2001): pp. 194-205.

41. Handa MR. A contribution to our knowledge of fresh water algae of Rangoon. *Journal of the Burma Research Society,* 17 (1927a): 259-269.

42. Handa MR. A notes on two species of *Chaetophora* from Rangoon. *Journal of the Burma Research Society,* 17 (1927b): 257-258.

43. Iqbal PJ, Kumar R and Pandit AK. Impact of effluents on phytoplankton dynamics in Dal Lake of Kashmir Himalaya. *Journal of Himalayan Ecology and Sustainable Development,* 3 (2008): 33-34.

44. Iyengar MOP and Desikachary TV. Volvocales. Monograph on Algae. Indian Council of Agricutlure Research New Delhi, (1981): pp. 532.

45. Kant S and Kachroo P. Limnological studies in Kashmir lakes. IV. Seasonal dynamics of phytoplankton in the Dal and Nagin. *Proceedings of the Indian National Science Academy,* 40 (1973): 77-99.

46. Kaushik S, Kulshreshtha S, Kushwan R, Agarkar MS and Saxsena DN. Some rare and interesting Chlorococcales from Madhya Pradesh. New addition to algal flora of India. *Acta Botanica Indica*, 21 (1991): 300-302 and 267-269.

47. Khan MA. Phycological studies in Kashmir I. Algal Biodiversity. Ecology Ethology and Aquatic Biota. Daya Publ. House New Delhi, (2002): 387-404.

48. Khare R and Suseela MR. Fresh water algal flora of Corbett Tiger Reserve, Uttaranchal, India. *Annals of Forestry,* 12.2 (2004): 233-242.

49. Kuetzing FT. Phycologia germanica. Deutschlands Algen in bundigen Beschreibungen, Nordhausen, (1845): pp. 340.

50. Kuetzing FT. Species Algarum, Lipsiae, (1849): pp. 922.

51. Kumar R, Seth MK and Suseela MR. Cyanophycean flora of Kangra district of Himachal Pradesh. *Phykos,* 43.1 (2013): 1-7.

52. Lund JWG. Contributions to our knowledge of British algae-VIII. *Journal of Botany London*, 80 (1942): 57-73.

53. Lund JWG. Contributions to our knowledge of British algae-XIII. *Hydrobiologia*, 6.1.2 (1954): 136-143.

54. Lund JWG. Three new species from Lake District. *Ibid,* 7.3 (1955): 219-29.

55. Lund JWG. Species of *Characiopsis, Pseudostaurastrum* and *Scenedesmus* new to Britain. *Naturalist London*, (1956): 13-16.

56. Lund JWG. Four new green algae. *Rev. Algol. N.S.*, 3 (1957): 26-44.

57. Lund JWG. Some New British algae. *Naturalist London*, (1960): 89-96.

58. Mir AM and Kachroo P. Limnology of Kashmir lakes. VII. The ecology of Bacillariophyceae in two lakes in Srinagar. *Proceedings of the Indian National Science Academy,* 2 (1982): 378-390.

59. Misra JN. Zygnemataceae of Kashmir. *Proceedings of the Indian Academy of Science Section*, 5.3 (1937): 110-117.

60. Misra PK, Mehrotra RK, Prakash J and Srivastava AK. Fresh water algae from Basti district Uttar Pradesh. *Geophytology,* 31 (2001): 1-7.

61. Misra PK, Prakash J, Srivastava AK and Singh PK. Some fresh water planktonic algae from Sant Kabir Nagar, Uttar Pradesh. *Phytotaxonomy*, 4 (2004): 87-94.

62. Mukhopadhyay A and Chatterjee P. A check list of blue-green algae from the paddy fields of 24-Parganas and Howrah district of West Bengal-1. *Phykos*, 20.1.2 (1981): 81-84.

63. Pandey UC and Pandey DC. Diatom flora of Allahabad, India-1. *Proceedings of the Indian National Science Academy,* 46.3 (1980): 350-355.

64. Pattanaik B and Adhikary SP. Blue green algal flora at some Archaeological sites and monuments of India. *Feddes Repertorium*, 113.3.4 (2002): 289-300.

65. Pham MN, Tan HTW, Mitrovic S and Yeo HHT. A checklist of the algae of Singapore, 2nd edn. Raffles museum of biodiversity research. National University of Singapore, Department of Biological Sciences, (2011).

66. Philipose MT. Chlorococcales, monograph on algae. Indian Council of Agricultural Research, New Delhi, (1967): pp. 365.

67. Prasad BN and Singh Y. Algal indicator of pollution. Bishen Singh and Mahendra Pal Singh Publication, Dehra Dun, India, (1996): pp. 226.

68. Prasad BN, Srivastava MN and Khanna P. Some blue-green algae of Pachmarhi, Madhya Pradesh. *Journal of the Indian Botanical Society*, 65 (1986): 323-328.

69. Prescott GW. Iowa Algae. University of Iowa studies in natural History, 6 (1931): 1-235.

70. Prescott GW. Notes on the Desmid flora of New England II. *Rhodora,* 37 (1935): 113-121.

71. Prescott GW. Notes on algae of Gatun Lake, Panama canal. *Transactions of the American Microscopical Society*, 4 (1936a): 501-509.

72. Prescott GW. Notes on Alpine and subalpine Desmids from western United States. Pap. *Michigan Academy of Science Arts and Letters,* 11 (1936b): 135-146.

73. Prescott GW. Preliminary notes on the desmids of Isle Royale. Pap. *Michigan Academy of Science Arts and Letters*, 22 (1937): 201-213.

74. Prescott GW. Monograph, Algae of the Western great lakes area. Exclusive of Desmids and Diatoms. Cranbrook Institute of Science, Michigan. Wm. C. Brown Co. Publishers, Dubuque Iowa, (1951): pp.

944.

75. Prescott GW and Magnotta A. Notes on Michigan Desmids with Descriptions of some species and varieties new to science. *Michigan Academy of Science Arts and Letters*, 20 (1935): 157-170.

76. Prescott GW and Scott AM. Some south Australian Desmids. *Transactions of the Royal Society of South Australia*, 75 (1945): 55-69.

77. Prescott GW, Silva H and Wade HE. New interesting freshwater algae from North America. *Hydrobiologia,* 2.1 (1949): 84-91.

78. Ralfs J. The British Desmidiaceae. London, (1848): pp. 226.

79. Ramanathan KR. Ulotrichales monograph. Indian Council of Agricultural Research, New Delhi, (1964): pp. 188.

80. Randhawa MS. *Ghosella indica*-A new member of the conjugatae. Gen. et sp. nov. *Journal of the Indian Botanical Society*, 13.1 (1934): 11-16.

81. Randhawa MS. A note on some attached forms of *Spirogyra* from the Punjab. *Proceedings of the Indian Academy of Sciences*, 4.3 (1936b): 246-249.

82. Randhawa MS. Three new species of *Zygnema* from Northern India. *Proceedings of the Indian Academy of Sciences,* 4.3 (1936c): 239-245.

83. Randhawa MS. Observation on some Zygnemales of N. India. Pt. II. *Proceedings of the Indian Academy of Sciences*, 8 (1938a): 4.

84. Randhawa MS. *Zygonium kumaoensis*, a new species of *Zygogonium* from Kumaon. *Journal of the Indian Botanical Society*, 19.5.6 (1940): 247-249.

85. Randhawa MS. *Sirocladium* a new terrestrial member of the Zygnematales. *Botanical Gazette,* 103.1 (1941b): 192-197.

86. Randhawa MS. A critical review of some recently created new species of Indian Zygnematales. *Proceedings of the Indian Academy of Sciences*, 18.4 (1943): 73-81.

87. Randhawa MS. A note on two new species of *Spirogyra* and *Sirogonium*. *Journal of the Indian Botanical Society*, 37 (1958): 380-381.

88. Randhawa MS. Zygnemataceae. Indian Council of Agricultural Research, New Delhi, (1959): pp. 478.

89. Randhawa MS and Venkatraman GS. Notes on some Cladophorales from India. *Proceedings of the National Institute of Sciences of India,* 27.2 (1961): 52-55.

90. Scott AM and Prescott GW. Notes on Indonesian Fresh water algae I. *Staurastrum wildmani* Gutw. *Reinwardtia*, 3.3 (1956): 105-112.

91. Scott AM and Prescott GW. Notes on Indonesian Freshwater algae III. New varieties of some little known Staurastra (Desmidiaceae). *Reinwardtia*, 4.3 (1958): 1-14.

92. Scott AM and Prescott GW. Notes on Indonesian Fresh water algae IV. Concerning *Euastrum* Moebii (Borge) Scott & Prescott Comb. nov., and *Euastrum turgidum* Wallich. *Reinwardtia*, 5.3 (1960): 317-334.

93. Scott AM and Prescott GW. Indonesian Desmids. *Hydrobiologia,* 17 (1961): 132.

94. Shafiq-ur-Rehman. Pollution in the red-bloomed Himalayan Dal Lake of Kashmir, 9 (2009).

95. Srivastava A and Roy I. Bio-Nano-Geo-Sciences: The future challenge. Ana Book Pvt. Ltd., New Delhi, pp. 81-94.

96. Singh A, Tiwari V and Mohan J. Chroococcales in river Ganga at Jajmau Ghat, Kanpur. *Tropical Plant Research*, 1.1 (2014): 28-30.

97. Singh RN. Contribution to our knowledge of the fresh water algae of Northern India–I, Oedogoniales. *Proceedings of the Indian Academy of Science*, 4.2 (1936): 97-107.

98. Srivastava N, Suseela MR and Toppo K. Fresh water cyanobacteria of Sai River near Lucknow, Uttar Pradesh. *Tropical Plant Research,* 1.2 (2014): 11-16.

99. Suseela MR and Dwivedi S. A contribution to fresh water Algal flora of Bundelkhand region of Uttar Pradesh. (Chlorophyceae and Xanthophyceae). *Phytotaxonomy*, 1 (2001): 76-81.

100. Suseela MR and Dwivedi S. A contribution to fresh water algal flora of Bacillariophyceae from Bundelkhand region of Uttar Pradesh, India. *Phytotaxonomy,* 2 (2002): 33-39.

101. Suseela MR and Toppo K. Contribution to the desmid flora of Sikkim Himalayas, India. *Bulletin of the National Museum of Nature and Science*, 33.3.4 (2007): 105-114.

102. Suseela MR and Toppo K. Occurance of rare desmids and their addition to Indian algal flora. *Journal of the Indian Botanical Society*, 89.3.4 (2010): 320-323.

103. Suseela MR and Toppo K. Occurance and diversity of *Staurastrum* species in lentic water bodies of Chhatisgarh state, India. *Annals of Forestry,* 19.1 (2011): 80-90.

104. Tiffany LH and Britton ME. Monograph on the Algae of Illinois. Hofner Publishing Company, The University of Chicago press. New York, (1952): pp. 407.

105. Toppo K and Suseela MR. Enumetation of *Scenedesmus* species in Chhattisgarh, India. Indian *Journal of Applied and Pure Biology*, 24.2 (2009): 397-404.

106. Turner WB. The fresh water algae Principally Desmidiaceae of East India. Kungliga Svenska

VetensKaps Akademicins Handlinger, 25.5 (1892): 1-187.

107. Wanganeo A and Wanganeo R. Algal population in valley lakes of Kashmir Himalaya. *Archiv fur Hydrobiologie,* 12 (1991): 219-233.

108. West W and West GS. A contribution to our knowledge of the fresh water algae of Madagascar. *Transactions of the Linnean Society of Botany*, *London* 2nd Ser, 5.2 (1895): 41-90.

109. West W and West GS. A contribution to the fresh water algae of the south of England. *Journal of the Royal Microscopical Society,* (1897): 467-511.

110. West W and West GS. On some desmids of the United States. *Journal of the Linnean Society of London,* 33 (1898): 279-322.

111. West W and West GS. A contribution to the fresh water Algae of Ceylon. Transactions *of the Linnean Society of Botany, London,* 6.3 (1902): 123-215.

112. West W and West GS. Fresh water algae from Burma including Bengal and Madras. *Annals of the Royal Botanic Garden Calcutta,* 6 (1907): 175-260.

113. West W, West GS and Carlex N. A monograph of the British Desmidiaceae. *Royal Society of London,* 5 (1923): 1-300.

114. Zutshi DP and Vass KK. Limnological studies on the Dal Lake, Srinagar III. Biological features. *Proceedings of the Indian National Science Academy*, 48 (1982): 234-241.

Cite this article as:

Javeed Ahmad Lone, Farooq Ahmad Lone, Mekhla Ratna Suseela. A review on phycological studies with special emphasis on Kashmir Himalayan Valley: Algal Biodiversity. *Annals of Plant Sciences 6.12 (2017) pp. 1879-1885*.

doi: http://dx.doi.org/10.21746/aps.2017.6.12.14

Source of support: Nil
Conflict of interest: Nil